N71-37635

NASA TECHNICAL TRANSLATION NASA TT F-13,996

CONTINUOUS MEASUREMENT OF THE ACTION OF POTASSIUM AND SODIUM WITHIN THE INTERSTICE OF MUSCLE STRIA DURING PHYSICAL EXERCISE

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Translation of "Mesure continue de l'activité du potassium et du sodium dans l'interstice du muscle strié durant l'exercice musculaire, Journal de Physiologie," Paris, Vol. 62, No. 53, 1970, pp. 380

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 OCTOBER 1971

CONTINUOUS MEASUREMENT OF THE ACTION OF POTASSIUM AND SODIUM WITHIN THE INTERSTICE OF MUSCLE STRIA DURING PHYSICAL EXERCISE

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ABSTRACT: The levels of potassium and sodium in the interstitial fluid of muscles have been continuously measured, at rest and during exercise, with ion specific glass microelectrodes. The values found and their known vasodilating effects correlate well with the functional hyperemia observed in muscles during exercise.

INTRODUCTION

In muscles, the level of potassium in the venous blood increases with muscular exercise. A simultaneous increase in the level of potassium of the arteries results in vasodilation with hyperemia. Thus, variation in the potassium levels are related to the hyperemia mechanism in muscular activity.

The exact size of the increase in the potassium levels near the residence vessels and its mode of change has not been known until now. Previous research has limited itself to the intermittent measurement of the levels of potassium in the venous blood. Yet, such levels in the blood are not exact measurement of the interstitial levels of potassium because the diffusion capacity of the vascular system is not sufficient to reach equilibrium in periods of increased irrigation.

With the development of ion specific glass electrodes for potassium and sodium, it has become feasible to continuously measure the local changes in the activity of these ions. We have built microelectrodes, mounted in inert glass, with tips close to 50 μ in diameter; we have used here NAS $_{11-18}$ glass (Corning Glass Works, New York, provided by Dr. Hébert) and also pMe glass (Jenaer Glaswerke Schott, Mayence). The microelectrodes have an internal resistance ranging from 10^9 to 10^{11} ohms. The potassium electrodes are only three times as selective for potassium as for sodium. Therefore a simultaneous measurement of K and Na had to be made, and the potassium levels corrected later in function of the variations in the sodium levels.

[1] Presented by R. Flandrois; Institute of Physiology, University of Tübingen and Ulm, Germany.

* Numbers in the margin indicate foreign pagination.

The studies have been made on urethane anesthesied rabbits. The following values were measured: 1. K and Na activities in blood samples from the femoral vein, at rest and after direct stimulation of the leg muscles; 2. simultaneous continuous recording of the K and Na activities in the femoral venous blood and of the blood flow in the femoral artery, using an electromagnetic flowmeter. These measures were conducted at rest and while stimulating the muscle at various frequencies; 3. changes in K and Na activities in the interstitial fluid of the muscle during muscular activity.

The results have been as follow: 1. the basal levels for K (4.2 ± 0.8 mmol/l) and for Na (134.4 ± 4.0 mmol/l) in the blood have matched the values obtained by flamme photometry; 2. K activity did raise to 6-6.5 mmol/l and Na activity to 140 mmol/l in the muscle venous blood during muscular exercise; 3. K activity did raise faster and higher in the interstitial fluid than in the blood. With high frequency of stimulation a level of 8-9 mmol/l is reached for K; 4. K activity change in the blood and in the interstitial fluid is concomittant with hyperemia.

If the vasodilating effect of similar concentrations of K in vivo and in vitro is considered, the role of these ionic shifts in the control of functional hyperemia appears quite likely.